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# *Further Investigation of the "Two Method" Personal Equation.* By Walter W. Bryant.

In a former paper (*Monthly Notices*, 1898 March) I gave an analysis of the results of five years' determinations of the differences of personality between the eye-and-ear and galvanic method for H., A. C., and B., whenever a clock-star was observed by either of them both ways the same night, as part of the routine of the observatory at Greenwich.

The additional evidence since accumulated may throw fresh light upon some of the points then raised.

It may be well to note briefly, as before, that the quantity under discussion is very fairly represented by $t_h + t_c$ for H., who observes galvanically by the "sensorial" method, and by $t_h$ for A. C. and B., who adopt the "muscular" method, $t_h$ being the "reaction to sound," and $t_c$ the time occupied in making a contact, which is theoretically eliminated in the "muscular" method.

Some of the more ordinary causes of variation may be classified as follows:—

A. Personal, the observer's physical, and especially nervous, condition with regard to—

(1) General health, age, &c.

(2) Time of year, time of day, temperature and other external influences.

(3) Comfort at the moment, depending upon observing position (standing, sitting, or reclining), including the inclination of the head with reference to the clock, &c., &c.

B. Impersonal, depending on instruments.

(1) The pricker chronograph is open to the objection that the slight tendency to stop the barrel may introduce a variation in the accuracy of the clock comparison depending upon the fraction of a second between the beats from the two clocks.

(2) Galvanic circuits are liable to vary in resistance, especially at contacts, with heat, cold, damp, &c.; but this cause is probably insignificant.

(3) From a cause possibly connected with (1) the seconds of Clock Hardy, the transit clock, do not appear to be of the same length, the odd seconds giving a reading differing from that of the even ones.

(4) The force necessary to make a contact varies with the strength of the spring. A new spring tends to make all galvanic observations a little late. If this is delicately adjusted to avoid the difficulty it is found that some

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observers make involuntary contacts, which is a far greater evil.

C. Impersonal, depending on—
(1) Optical conditions, brightness of sky, fineness of definition, &c.; also wind, which may affect $t_h$.
(2) Stellar magnitude, which, however, in the case of clock stars, is not supposed to be so important as for fainter stars.

There is also at times a gratuitous error introduced if the clock comparison is not automatic, which is liable to cancel if not more than cancel $t_h$, since the dead-beat escapement is not adapted for the "muscular" method of observation (see previous paper for other notes on observing clock).

In the present paper I am only concerned with the effects of A, though C is implicitly involved in A (2).

A (1). One would expect that, as a young observer gains experience, if he adopts the "muscular method" for galvanic observations, his "two-method" P.E. will tend to diminish. But as the effect of age is probably, after a certain time, to slacken mental processes, it seems probable that there is a limit to this diminution, and that at a later period the P.E. will increase.

N.B.—In all that follows suffixes stand for number of single stars observed, and times are given as they were actually observed. I have not reduced any of them to the equator, since neither $t_h$ nor $t_c$ is a function of arc, but only of time, and $t_s$, the "reaction to light," does not appear in the "two-method" P.E. I have also refrained from loading the observations with varying figures for probable error. Those I have determined vary from $\pm^s$·04 to $\pm^s$·08 approximately for a well-determined group, but are naturally greater for poor determinations.

The first table shows annual variation only.

| | 1893. | 1894. | 1895. | 1896. | 1897. | 1898. | 1899. | 1900. |
|---|---|---|---|---|---|---|---|---|
| | s | s | s | s | s | s | s | s |
| H. | +·441$_{78}$ | +·481$_{40}$ | +·438$_{80}$ | +·527$_{39}$ | +·508$_{45}$ | +·549$_{32}$ | +·572$_{28}$ | +·603$_{33}$ |
| A.C. | +·107$_{69}$ | +·093$_{24}$ | +·062$_{22}$ | +·071$_{17}$ | +·082$_{25}$ | +·040$_{37}$ | +·018$_{72}$ | +·019$_{63}$ |
| B. | −·004$_{196}$ | +·056$_{109}$ | +·040$_{124}$ | +·016$_{141}$ | +·025$_{85}$ | +·015$_{154}$ | +·012$_{180}$ | +·034$_{196}$ |

If we smooth the above by taking means of three consecutive years, the result is striking.

It is unfortunate that the curve for H. cannot be traced back, neither A.C. nor B. having yet reached the standing of H. at the beginning of the series of observations. I am not sure whether to expect a minimum for the "sensorial" method, but if so H. appears to have passed it. In a few years' time the curves for A.C. and B. ought to give a fair test to my experimental theory. B. seems to be inclined to turn back already, but that may be accidental (a new spring, see above, B (4), was fitted in 1900).

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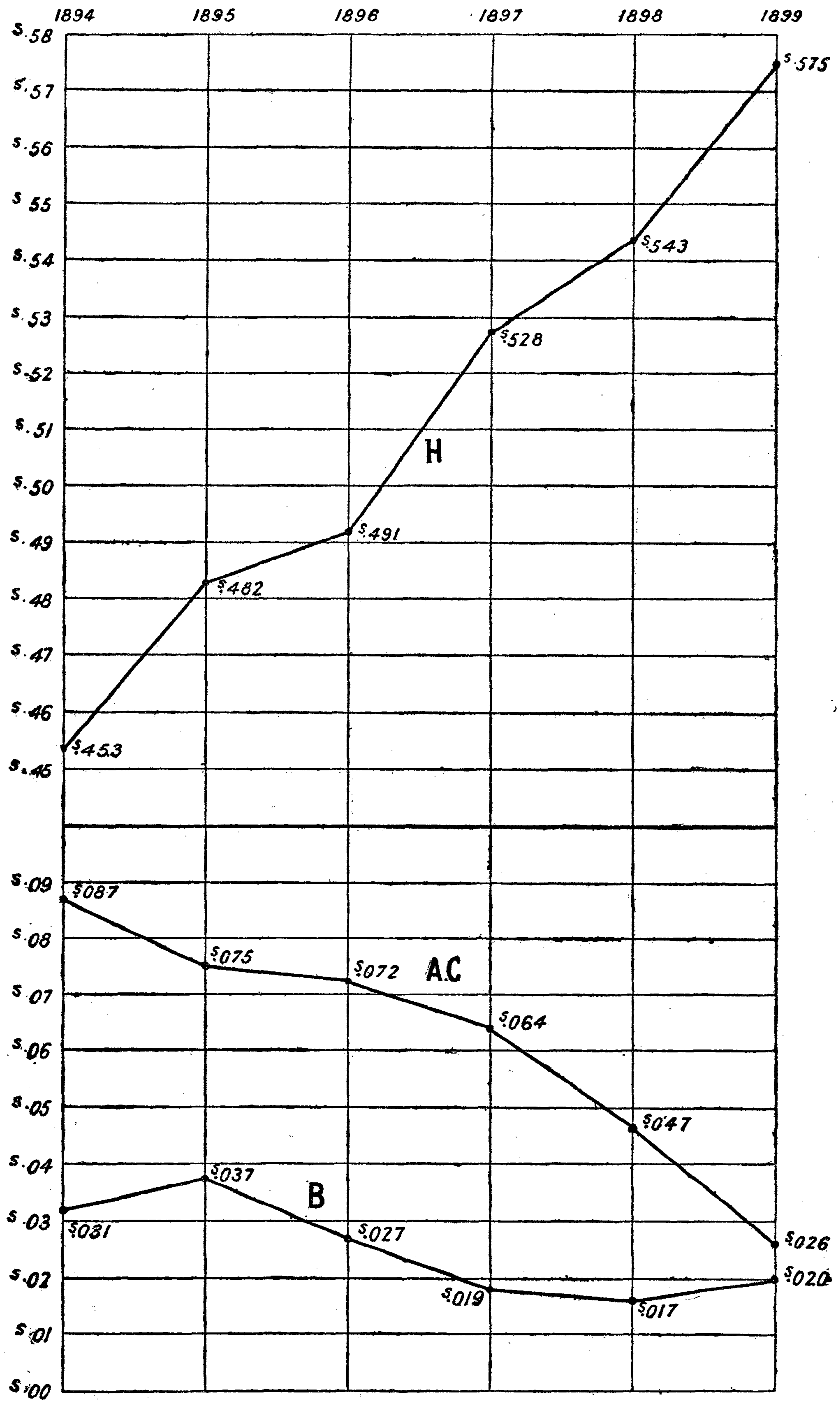
It must be remembered in connection with H.'s curve that he is not a "muscular" observer, and so the ascent of the curve may




have some other explanation apart from the one suggested above.

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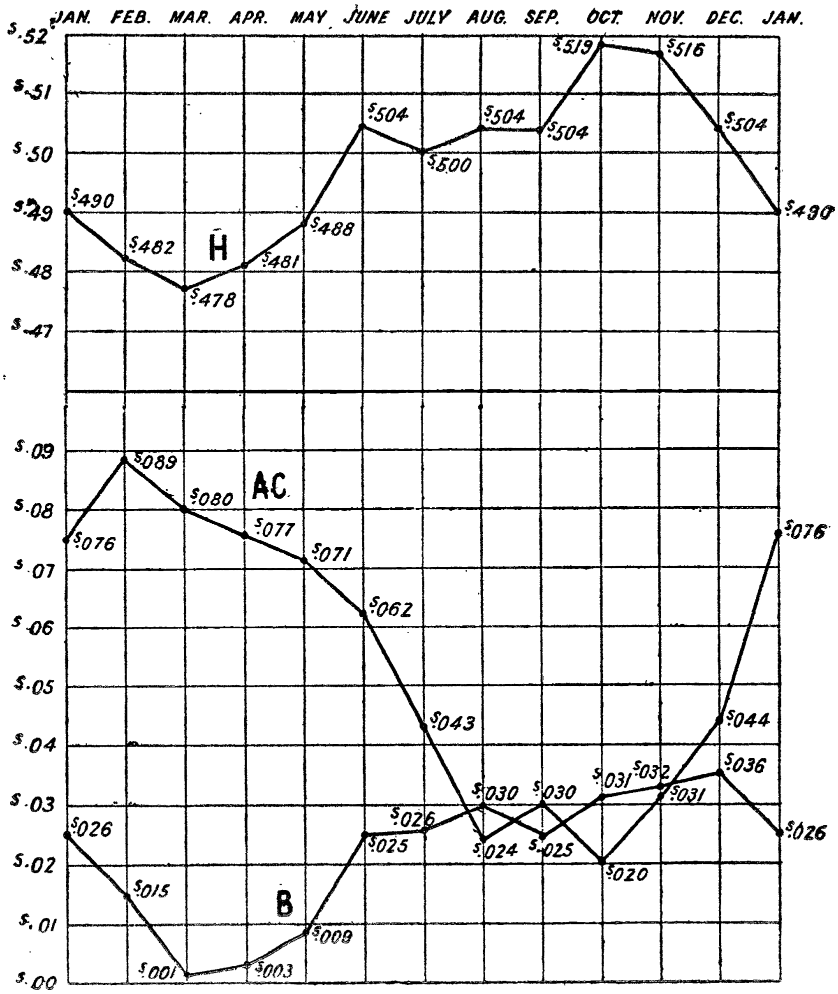
A (2). As regards time of year.

| | H. | A.C. | B. |
|---|---|---|---|
| | s | s | s |
| January | +·493 22 | +·087 19 | +·029 88 |
| February | +·470 29 | +·095 20 | +·011 84 |
| March | +·483 39 | +·086 38 | +·006 112 |
| April | +·481 40 | +·058 38 | −·014 80 |
| May | +·478 49 | +·087 39 | +·018 120 |
| June | +·504 38 | +·068 24 | +·024 80 |
| July | +·530 28 | +·032 19 | +·033 43 |
| August | +·467 27 | +·030 24 | +·021 123 |
| September | +·516 24 | +·011 39 | +·035 122 |
| October | +·529 31 | +·048 26 | +·019 137 |
| November | +·511 24 | +·001 19 | +·040 121 |
| December | +·508 14 | +·045 23 | +·038 83 |

Smoothing as before, three months at a time, we obtain the following results :—

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Within limits the curves for H. and B. are similar, with a well-marked minimum in the spring, a maximum towards the end of the year, and a straight piece in the summer.

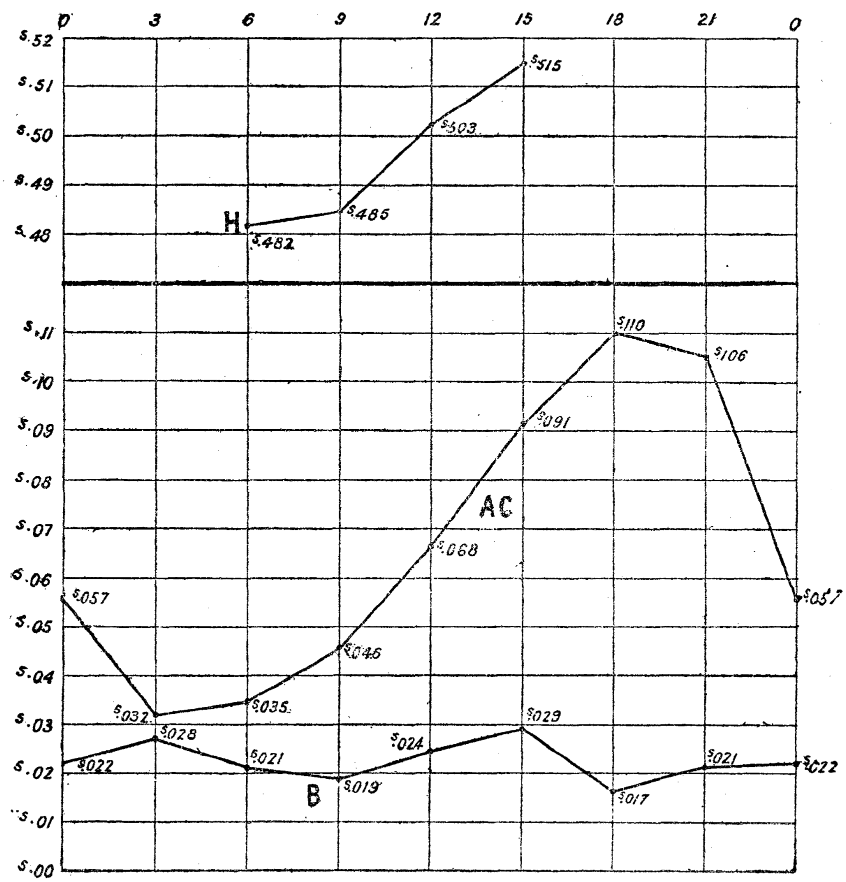
A.C., on the other hand, has a strong minimum in the autumn and a maximum at the beginning of the year.

It is not immediately clear what can be made of these results, but they are interesting even if the weights of the observations are too low to encourage theorising.

Next as regards time of day. Three hour groups.

| G.M.T. | H. | A.C. | B. |
|---|---|---|---|
| h | s | s | s |
| 0 | — | +·058$_{5}$ | +·057$_{9}$ |
| 3 | +·510$_{2}$ | +·025$_{11}$ | +·028$_{87}$ |
| 6 | +·454$_{41}$ | +·027$_{50}$ | +·014$_{298}$ |
| 9 | +·496$_{134}$ | +·054$_{126}$ | +·020$_{319}$ |
| 12 | +·506$_{164}$ | +·058$_{103}$ | +·024$_{230}$ |
| 15 | +·507$_{23}$ | +·093$_{18}$ | +·027$_{38}$ |
| 18 | +·531$_{14}$ | +·123$_{12}$ | +·037$_{80}$ |
| 21 | — | +·120$_{1}$ | −·012$_{26}$ |

All three show a similar effect, possibly due to fatigue, between $6^{h}$ and $15^{h}$.

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Beyond that there is not the same meaning to the curve, as observations at $18^h$ indicate, not a long duty, but a short special one, denoting Moon about third quarter.

A (3). Dividing the stars into groups of 10° N.P.D.

| N.P.D. | H. | A.C. | B. |
|---|---|---|---|
| ° | s | s | s |
| 51–61 | $+ \cdot 488_{26}$ | $+ \cdot 040_{37}$ | $+ \cdot 010_{98}$ |
| 61–71 | $+ \cdot 473_{90}$ | $+ \cdot 055_{75}$ | $+ \cdot 031_{231}$ |
| 71–81 | $+ \cdot 481_{75}$ | $+ \cdot 073_{67}$ | $+ \cdot 020_{280}$ |
| 81–91 | $+ \cdot 508_{113}$ | $+ \cdot 049_{82}$ | $+ 027_{274}$ |
| 91–101 | $+ \cdot 498_{41}$ | $+ \cdot 035_{39}$ | $+ \cdot 016_{173}$ |
| 101–111 | $+ \cdot 547_{23}$ | $+ \cdot 071_{16}$ | $+ \cdot 013_{94}$ |
| 111–121 | $+ \cdot 503_{8}$ | $+ \cdot 092_{10}$ | $+ \cdot 013_{40}$ |

Here the first three groups correspond fairly well with stars observed in more or less recumbent, and the last three in practically upright position, though for about the middle group, and for five or six degrees each side of it, stars may be observed also kneeling, sitting, or stooping.

A smoothed curve seems therefore out of place, and a rigid line for attitude cannot be drawn either, so that I think the figures should be left to speak for themselves, with the note that $^s\cdot 003$ is greater than the maximum effect of change of distance from observing clock, so that that will not of itself account for the great increase in H. for low stars, and still less will it account for B.'s results. I have investigated the latter more closely for groups of five degrees, three degrees, and one degree (as well as for single hours of G.M.T. in the previous table), and though the results seem too cumbersome and undecided to be worthy of insertion here I may mention that there is a marked maximum at about 70° N.P.D., and that the smallest values appear to belong to the high stars and those below the equator, so that I should conclude that the erect position is the best, but that as the angle of inclination of the head to the direction of the sound of the clock varies, there is a critical angle between the vertical and horizontal, for which the reaction to sound is slowest. An analogous idea was presented to the society by A. W. Roberts as the result of his photometric observations, *i.e.* that there is a critical angle for the sight, two equal sources of light not appearing equal in all positions of the observer.

It seems to me that the part of A (1) which is beyond ordinary investigation, viz. the uncertain condition of the observer's nervous system (or digestion), rendering extended comparisons misleading, is the difficulty which tends most to weaken these results. A long series of experimental observations of this kind is out of the question at Greenwich, the transit circle having a vast amount of work to do, of which these comparisons form but one small item.

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Nevertheless I hope in a few years' time to be able to extend this investigation a little further, and to open up one or two fresh lines of research in this psychologically interesting field.

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*Anomalous Occultations of Stars by the Moon.* By R. T. A. Innes.

It is well known that on several occasions double stars have been discovered through the phenomena attending their occultation by the moon.

Cases in point are the discovery by Professor Barnard in 1883 of the duplicity of Bradley 2607, the star which is closely preceding $\beta$ *Capricorni*, and the discovery by Burg of Vienna in 1819 that *Antares* is a double star.

Another remarkable instance, but not so well known, is that of P. XVI. 68. On 1836 September 16 Sir Thomas Maclear, using a 3-inch telescope, observed the occultation of this star, and remarked that the star "disappeared gradually."

Fifty-three years later Burnham, with the 36-inch Lick refractor, found this to be a double star ($\beta$ 1115).

In my own experience unusual occultations of many stars have been observed, and some of these were afterwards found to be known pairs, viz.

BD. $-22°$, 3908. "Glided out, took $0^s.5$ to disappear." This is $\beta$ 809, mags. 8·6 and 10·2, distance 1·6″.

P. XIII. 126. "Began to fade at $25^s.7$, disappeared at $28^s.0$, good." This is $\beta$ 932, 0·44″.

The slow progression of the moon amongst the stars (about 0·55″ in one second of time) and the sharp character of a good disappearance at the dark limb should similarly disclose the presence of double stars of exceeding closeness, or of stars having a measurable diameter. The greater number of dark-limb occultations are seemingly instantaneous; the exceptions are of two classes:

(A) The star disappears in two distinct stages.

(B) The star disappears gradually, or glides.

When a star disappears in two distinct stages, there is a high presumption that it is really a double star; and at first sight it would appear that the phenomena of "gliding" occurs when a star has a disc of such a size that it is not instantaneously obliterated by the advancing moon. But "gliding" is actually found to occur with double stars, as is shown in the cases of $\beta$ 809, $\beta$ 932, and $\beta$ 1115 quoted above. It may there-

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